METHOD

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Analysis of elemental composition of particulate matter and its health impact on the plateau state, Nigeria

Hemba EC, Ikyumbur TJ✉, Trisma EA

Department of Physics, Federal College of Education, Pankshin, Plateau State, Nigeria

✉**Corresponding author:**
Department of Physics, Federal College of Education, Pankshin, Plateau State, Nigeria; E-mail: ikyumburtj@yahoo.com
ORCID: 0000-0002-6999-183X

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ABSTRACT

The PM sampling respirable dust sampler (AMP 460 NL) and microphone slides were used to collect dust particles. The filter paper was insert between the top covers and filter adaptors assembly of the machine after measuring the initial weight. The particle trapped on a filter paper was carefully washed into a beaker using a wash bottle up to 20ml and the AAS 6800 model was used to analysed various element. The results obtained were recorded in parts per million (ppm). The particle trapped by slides used to measure the particle diameter. The particle diameter for each location was used to calculate the terminal velocity, residence time and horizontal stopping distance. The results revealed that the dust particles are accompanied with nickel, cadmium, manganese, sodium, magnesium, calcium and copper. The particles also take about 2 to 3 minutes in air.

Keywords: Analysis; elements; composition; particulate matter; health; impact

1. INTRODUCTION

The world all over has identifies air pollution as one of the biggest environmental risks to health. There are serious evidences pointing to the fact that Nigeria has the world's worse polluted cities. The burning of rubbish, oil spillage, extensive use of generators, high traffic volume, the use of wood stove and charcoal stove for cooking, burning of old tires and roasting of meat with old tires couple with the rain of dust on roads or harmattan wind has made Nigerian cities one of the worst polluted in the world. The fine particulate matter ($PM_{2.5}$) value of 999 $\mu g/m^3$ and the 985 $\mu g/m^3$recorded in Onitsha and Port Harcourt respectively [1] and the 594 $\mu g/m^3$ recorded in Otukpo Benue State [2] are clear evidence of unsafe air in the country. Other cities with reported cases excessive pollution are Kano, Kaduna, Lagos, Aba, Umuahia, Owerri, Jos etc. [3]; [4]; [5]; [6]; [7]; [8]. Statistics have shown that the above mentioned cities are the most populated and fast growing in Nigeria.

The available information on Nigerian cities has shown a rapid population growth in recent years. The World Bank has estimated that about 85 million Nigerians currently live in the cities [9]. This goes to show that the 85 million people are constantly inhaling unsafe air daily. Recent research works in Nigeria have linked some prevalent diseases such as complicated coughing, sneezing, allergic asthma, pulmonary, tuberculosis, pneumonia, upper respiratory tract infection, chronic bronchitis, cardiovascular diseases and visual impairment to unsafe air [10]; [11]; [12].

The WHO's International Agency for Research on Cancer (IARC) in 2013 also associated cancer incidence most especially cancer of the lung with outdoor air pollution, particularly the particulate matter component of the air pollution. An association also has observed the relation between outdoor air pollution and increase in cancer of the urinary track/bladder [14]. Most of the diseases associated to outdoor air population can be link to the elemental composition of the particulate matter.

The following elements have been identifying to be commonly found in air: nickel, magnesium, sodium, potassium, manganese, cadmium, calcium, copper etc [15]; [16]; [17]; [18]; [19]; [20]. Inhaling air contaminated with these elements or its compounds can be catastrophic to one's health.

It is divulged that most of these elements has adverse effects range from acute to chronic. The acute inhalation exposure to high levels of manganese dust for instance, can cause inflammatory response in the lung and the chronic effect can result into parkinson's disease with symptoms such as muscle tremor, reduced motor skills, difficulty and slow walking, slurred speech, and sometimes, psychiatric disturbances [17]. The inhalation exposure to nickel refinery and subsulfide and cadmium is known to be the major cause of respiratory effect, lung and nasal cancers, Insomnia, tightness of chest, non-productive cough, dyspnoea, sweating, visual disturbances, pulmonary irritation and kidney disease etc. [21]; [22]; [23], [24].

Air pollution is an issue of global concern and interest especially when it affects large city settlements. PM characterization has been an area of much interest in recent times because of its associated side effects. The link between air pollution and associated diseases is of importance, not only in disease control but in environmental impact studies. [10] opined that the decline in air quality in the country has serious effects on the people in the Central and Northern states of Nigeria that are predominantly farmers and therefore there is need for continuing program surveillance of our lower atmosphere. The research mentioned the probable associated health effect but did not give the size distribution (domino) and elemental composition (i.e. evidence) to implicate the PM as being the real cause of respiratory related diseases. Hence this research seeks to determine elemental composition of particulate matter, help avoid outbreak of epidemics and further degrading of air quality.

2. METHODOLOGY

The research design in this work is the experimental research.

PM Sampling using smeared Microphone Slides

The following apparatus were used: five wooden stands per site (each measuring 1.5m tall) with a flat top made of plywood measuring 30.0cm by 30.0cm; marked microscope slides lightly smeared with glycerine; clips pegs and dust wipers. Each of flattops has T-projection of 15.0cm above the flat top with nail whose head were cut off. This was to enable it hold a microscope slides suspended with the help of a peg in a vertical position.

Ten marked, smeared and pre-weighed microscope slides were used per wooden stand. Five microscopic slides were placed horizontally upward to collect particles, setting down unites the influence of gravity, while the other ones were suspended vertically with the aid of a clip-peg on the T-projection and held firmly plasticine, with the smeared surface facing the direction of the on-coming wind so as to trap the particles that will impact on it horizontally.

PM Sampling Respirable dust sampler (AMP 460 NL)

The samples were placed on the elevated plat form of 1.5m high and at a distance of 20cm from tall buildings, trees, fences etc. to avoid obstruction of the air, after setting the sampler, marked sample bottles were weighed and fixed under the conical hoppers, one at a time. Marked and pre-weighed filter papers were then clamped between the top covers and filter adaptors assembly of the machine. The filter covers were closed and the sampler switched on taking note of time.

The filter papers and sample bottles were removed after 8 hours and re-weighed to obtain their weight after exposure, M2. The volume of sampled air was obtained from flow meter reading and sampling time.

After the elapse of the exposure hour (12 hours) the slides were quickly removed and kept in a microscope slid box and immediately closed so as to prevent other particles from falling in the slide after the experimental hours.

Elemental Analysis

The sample trapped on a filter paper was carefully washed into a beaker using a wash bottle up to 20ml. A few drops of Nitric acid were added to make it up to a mark of 50ml of volumetric flask and allowed for minutes. This was then taken to the AAS 6800 model for various elemental analysis depending on the element required.

Sample was then aspirated to the machine through a neutralizer with the aid of an air pump to the mixing chamber of the monocrometor to the dictator. The dictator send signals to the readout were finally printed. Before analysing any element, a standard solution of each of the element was serially prepared to obtained standard curve. This was to enable us to extrapolate the unknown concentration from the standard curve. The results obtained were recorded in parts per million (ppm).

Atmospheric Particulate matter size measurement

The size of the sampled particles was measured using the digital microscope (optical microscope). The Celestron Cosmos Model with 4X-160X (power and digital zoom).

The microscope slide was examined by placing slide on the holder. The source of illumination was then switched on after the microscope was connected to the wall socket and knobs adjusted appropriately to bring to clear focus magnificent images of the particle matter capture on the slides. The slides were then examined. A total of seventy slides were examined per site. Twenty particles were randomly size to 1400. The average size of the sampled particle per site and the particle diameter were then obtained. The particle diameter (dp) measured were used to determine the terminal velocity.

Determination of parameters

The parameters such as terminal or setting velocity (U_t) of PM was determined by via stokes terminal equation;

$$U_t = \frac{g(\ell_p - \ell)dp^2}{18\mu} \quad (1)$$

Where ℓ_p is particle density, ℓ is density of air, dp is particle diameter and U_t is settling velocity. The residence time (τ) was determined with the equation below:

$$\tau = \frac{h_s}{u_t} \quad (2)$$

u_t is settling velocity and h_s is height above the ground and the third parameter was determine using the following equation:

$$X = V_0\tau \quad (3)$$

where τ is residence time, Vo is wind speed and X is horizontal stop distance

3. DISCUSSION

This work has established the presence of Copper, Nickel, Manganese, Calcium, Cadmium, Sodium and Magnesium in all study areas. However, Carbon monoxide was absent in all study areas.

The results revealed that Nickel was found in all the study areas most especially in dry season with actual concentration of 0.0542ppm, 0.0549ppm and 0.0443ppm for Pankshin, Shendam, and Bidabidi in Jos respectively. The major source of nickel to dust

in Plateau State may be smoking of tobacco, tilling of soil for mining and agricultural purposes, sediment and breaking of rock for commercial activities on the Plateau.

The work also confirmed the presence of Manganese (Mn) in the range of 0.0132ppm to 0.0354ppm in Pankshin and 0.0367ppm to 0.0648ppm in Shendam local government area of Plateau State. Manganese is usually a constituent of air. However, the high concentration may be because of application of inorganic fertilizers and herbicides by farmers in the study area.

Shendam and some locations in Jos such as Bidabidi and Farin Gada recorded the presence of Cadmium (Cd) in the range of 0.0066ppm to 0.0073ppm in Shendam, 0.0066ppm in Farin Gada and 0.0060ppm in Bidabidi during the dry season. A small concentration was found in raining season. The high concentration of cadmium can be associated with the burning of fossil fuels, application of phosphate fertilizers and incineration of municipal waste minerals and disposal in the study area.

The dust collected during the dry constitute a high concentration of Sodium (Na). The concentration in Shendam was between 0.5169ppm to 2.1712ppm, Farin Gada in Jos was between 0.6602ppm to 2.2176ppm and Pankshin 0.5869ppm to 1.4194ppm. The concentration was a bit low in Jos and Shendam but high in Pankshin ranging between 0.8897ppm to 1.0715ppm in raining season. The use of inorganic fertilizers on the farm may be the major source of sodium.

A concentration of 0.127ppm to 0.6706ppm of Magnesium in dry season was obtained in Jos, 0.058ppm to 0.868ppm in Pankshin and a concentration of between 0.0058ppm to 0.0107ppm in Shendam. The raining season also recorded high concentration of between 0.6490ppm to 0.6706ppm in Jos, 0.157ppm to 0.4785ppm in Shendam and 0.0064ppm to 0.0141ppm in Pankshin. The major sources of Magnesium in Plateau State may be from rocks and inorganic fertilizer.

The mining activities, decaying vegetation, waste disposals may be the major sources of the small concentration of copper found in Pankshin (i.e. 0.0014ppm to 0.0018pm) and Bidabidi (0.0011ppm) in Jos.

The terminal or setting velocity of 0.83m/s, 0.62m/s and 0.52m/s for Jos, Pankshin and Shendam respectively were determined. This was done in order ascertain the rate which the particles are suspended in air and estimate the particle's size. The terminal velocity for each location was also used to determine the residence time and horizontal stopping distance. The result revealed that the residence time in Jos, Pankshin and Shendam are respectively 1.81s, 2.42s and 2.88s whereas the horizontal stopping distance in Jos, Pankshin and Shendam was calculated to be 0.029m, 0.041m and 0.046m respectively. The residence time from this work implies that the particles are suspended in air for about 3 minutes in Shendam and about 2 minutes in both Jos and Pankshin.

4. CONCLUSION

A lot of research works conducted in Nigeria on the quality of air have pointed to the fact that the air quality is in a serious declined. Most of these researches have measured the particle's size and mentioned associated health effects of these particles. There are however fail to analysed the elemental composition of these particles. In this work, the particles were collected and the elemental composition of these particles were analysed. The particle's diameter was measured at each location and the results were used to determine the taken for the particle remain in air.

The work revealed that sodium has the highest concentration of 2.2176ppm in the dry season. This followed by magnesium, manganese, nickel, cadmium and copper with the concentration of 0.868ppm, 0.0648ppm, 0.0549ppm, 0.0073ppm and 0.0018ppm respectively. The concentration of sodium in raining season was also very high (i.e.1.0715ppm) when compare with the other elements studied in this work. The high concentration of sodium and magnesium may be due the high use fertilizer in the study areas.

The dust particles trapped by the filter paper revealed that elements such as nickel, manganese, sodium, cadmium, calcium, magnesium and copper were major constituents of the air. The particles in these areas remains in air for about 2 to 3 minutes and velocity reached by the particle as it falls through the air was approximately 1.0m/s.

The diseases such as tuberculosis, cerebrospinal meningitis, pneumonia, measles, chronic bronchitis, pertussis, pulmonary, complicated coughing, sneezing and acute respiratory infection, cardiovascular diseases etc. that are thought to have been associated to ambient air pollution [9]; [10]; [11] may be due to the presence of these elements.

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